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Engineered Landscapes: The New Dubai Canal and Emerging Public Spaces

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Abstract: Dubai's 2020 Expo is expected to authenticate Dubai's status as an emerging Arab city that displays modernity through iconic projects, sequences of fragmented urban enclaves, and engineered landscapes. The new Dubai Canal creates a navigational route that interlaces the historic centre with newly emerging artificial islands. The new Canal accentuates Dubai's city image as an urban space found on technologically advanced infrastructural systems, and offers new panoramas of the city, enhancing its walkability, and creating public spaces along its banks. This current paper studies the urban changes and the city's shift of focus manifest with these new waterfront developments. The attempt to unify the functions of the urban space, to live, work, move, and recreate in the same space is analysed as a departure from the fragmented practices existing until now. The recreation of historical forms and functions in a modern setup, and the attempt of Dubai to present itself as a global city through the use of architectural elements belonging to various cultures in order to appeal to different ethnicities are also discussed. Finally, in order to assess whether stagnation points would develop in the Canal which could jeopardize its function and appeal, a two-dimensional hydrodynamic model was utilized to predict the velocity and the circulation flow pattern in the canal, bends and lagoons.

1. INTRODUCTION

Dubai's historical background as a port city with a predominantly Indo-Persian mercantile community along Khor Dubai, today known as the Dubai Creek, is accentuated today by extensive shorefront developments. The port city that dates its urban origins to the time of Sheikh Saeed bin Maktoum (1912-1958) is witnessing rapid urbanisation schemes along engineered waterfronts, in the form of upscale residences, resorts, hotels, and shopping malls. This constantly changing city earned a reputation as a city of dreamscapes, resiliency to the surrounding desert environment, and aspired lifestyle for middle class expatriate communities. Dubai's urban policies are much debated among scholars as many regard that it caters to a community of consumption and to architecture of the spectacle (Acuto, 2010; Haines, 2011; Davis, 2007). Today Dubai disseminates a multitude of images overlaying the fragmented geometry of the 'No-stop-City' by continuously sprawling mega projects that are mini-Dubai's or partial-Dubai's, each project searching in different ways to "capture" or "project" some coherent if non-totalizing "essence" of the metropolitan city. Dubai's resilience likens it to a 'No-Stop-City', a term developed and presented in 1966 by a group of young Florentine architects, Archizoom Associates, through a manifesto that aimed to shed light on the problem of super-architecture and spatial quantity versus quality, and which coined the term 'cities without architecture' (Branzi, 2006).

In spite of Dubai's lack of significant oil reserves its urban policies succeeded in diversifying its GDP through the creation of iconic architecture, such as Burj Khalifa, the Dubai Mall, the Palm Islands, the Dubai Marina, and its most recent Bluewaters project. Dubai's risk management and resilience are still debatable since its fragility in the wake of economic crisis has not been wholly studied. However, this constantly changing city manages to re-emerge from economic crises, such as the one in 2008, and to continue to attract substantial numbers of tourists and entrepreneurs. The new Dubai Canal, if accompanied by integrated policies and plans towards inclusion, may represent a step towards mitigation and adaptation. Dubai's 'No-Stop-City' mantra is reflected in Dubai's new canal that connects Al-Shindagah and Al-Bastakiya historic neighbourhoods in Diera with contemporary urban enclaves along the shorefronts of the Arabian Gulf and Dubai's World Islands. Dubai's new canal enhances the hydraulic flow of sea water that initially ended in al-Jaddaf/Ras al-Khor and is expected to enrich the lagoon marine life as well as improve water quality by reducing water stagnation areas. This new form of waterfront urbanism questions the relation of such projects to nature, as land is reclaimed; and shorefronts are redesigned, creating favourable artificial landscapes/dreamscapes. In more recent history Frederick Law Olmsted's Central Park, with a large lake, advocated for proactively incorporating natural scenery in cities. Landscapes, including water canals, contribute to a sense of place, history, identity, and community. They have also been found to stimulate local economies, contributing significantly to urban and economic revitalization (Ellin, 2010). Orientation toward canals brings people closer to water, cultivates respect for local heritage and precious water resources, ultimately the most effective way to nurture stewardship. However, the new Dubai Canal devoured part of Al-Safa Park in order to provide a network of vibrant urban hubs along canals. Such a project in terms of planning and infrastructure revives Olmsted's adherence to naturalistic aesthetic in his designs, this required significant engineering works to create pedestrian paths, planting, brush-cutting, and digging of artificial ponds. The new canal (Figure 1) manifests how Dubai is constantly seeking to enhance its image and urban visibility as a city aware of the cultural diversity and needs of its inhabitants. Dubai's new shorefront developments reveal the essence of the presence of water not merely as a landscape feature, but ideologically, by connecting Dubai's past as a pearl fishermen port city to a modern urban enclave of spectacle and richness.

This current article aims primarily to provide a critical assessment of Dubai's new urban developments and landscape along the new Dubai Canal. In addition, given the concerns raised with low seawater velocities in previous projects in the city, which had resulted in stagnant and foul-smelling waters, this paper also aims to assess the hydraulic performance of the proposed Dubai artificial canal, through the use of a two-dimensional hydrodynamic model.

Figure 1. The new Dubai Canal from Al-Safa Park (photo-credit by the authors)

2. LITERATURE REVIEW

Dubai is a city that is constantly reshaping its urban image and brand value in order to diversify its economy, cater to investors and attract tourism as part of its strategy to reduce dependency on oil revenues. Mega projects target aspirations of the middle-class seeking lifestyles that mark them as successful entrepreneurs in a competitive global economy (Haines, 2011). There is no doubt that today the Arab world, and especially the Gulf state cities are becoming urbanised at diverse rates and with comparable characteristics. They have become perhaps more connected to a network of global cities and economies beyond their regional and cultural boundaries (Malkawi, 2008). Intensifying the urbanisation of Dubai's urban fabric through the addition of high-rise buildings and mega malls reflects an understanding that waterfronts are precious resources with unique potential for investment and diversified opportunities for economic development and public enjoyment. Although faced with economic challenges, Dubai is constantly pushing the limits of its waterfront projects, by, in addition to the Dubai Canal, the Palm Jumeirah, as the first of a series of artificial islands located off the coast of Dubai, manifesting clear geometries, and seen from above as a "palm tree" with a protective crescent-shaped offshore breakwater partially enclosing it. Land reclamation has become a favoured strategy for coastal and island city development as is evident from Dubai's most recent Bluewaters (artificial) island - Dubai Eye, in part because it is a means by which elite actors can create new urban spaces while bypassing cultural and stylistic forms in existing urban heritage (Grydehøj, 2015). Early examples such as the tourist resort of Madinat Jumeirah, completed in 2003, replicates forms and fragments of local heritage creating a resort along 5.4 kilometres of waterways, where visitors can take boat trips in order to replicate the experience of the traditional boats - Abra crossing the Dubai Creek. Today the Palm Jumeirah, the World Islands and Bluewaters island complement Madinat Jumeirah's waterfront/canal-scape developments in Dubai. Such waterfront landscapes are attractive for the predominantly expatriate community in Dubai, in search of recognizable fragmented vocabularies of tradition, by constructing a post-modern-staged authenticity form, experienced around an integrated urban-scape shaped by artificial canals (MacCannell, 1973) Jameson, 1990). Dubai's high-end shorefront developments reveal the essence of the presence of water not merely as a landscape feature but ideologically connecting Dubai's past as a pearl fishermen port city to a modern urban enclave of spectacle and richness. Engineered waterfronts and artificial islands brand the city as a financial powerhouse, capable of creating complex projects, and highlighting the profitability of a real-estate investment in it. This similitude is apparent in the organised hierarchy, but also eclecticism and pastiche creating façade differentiation that is adopted from a wide spectrum of motifs ranging from India to North Africa. Dubai is currently represented through images of the Burj Khalifa, the Dubai Mall, and Burj Al-Arab in the same manner that congregational mosques and their minarets represented Cairo and Istanbul (King, A., 2004).

3. METHODOLOGY

This study relies on theoretical analyses, observations, and modelling exercises. Recent urban planning concepts related to the city as a catalyst to urban regeneration and the recreation of historical forms and functions in a modern setup are discussed together with the power of new projects to change the focus, in the case of Dubai, from a high-rise, commercial architecture of the spectacular to one that will integrate history and present, various urban functions - living, recreating, moving - in the same space, and bring different ethnicities and socio-economic groups together. Observations of the space along the Dubai Canal and of the water movement in the Canal were conducted through various visits to the site. The development of artificial canals in Dubai and elsewhere has led in many cases to negative environmental aspects, where the water velocity in the canals remained too low, leading to excessive sediment deposition and algae growth on the canals' water, and foul-smelling odours from decomposed material due to the stagnation areas created. Therefore, this study utilized a computer model to simulate the flow condition in the Dubai Canal.

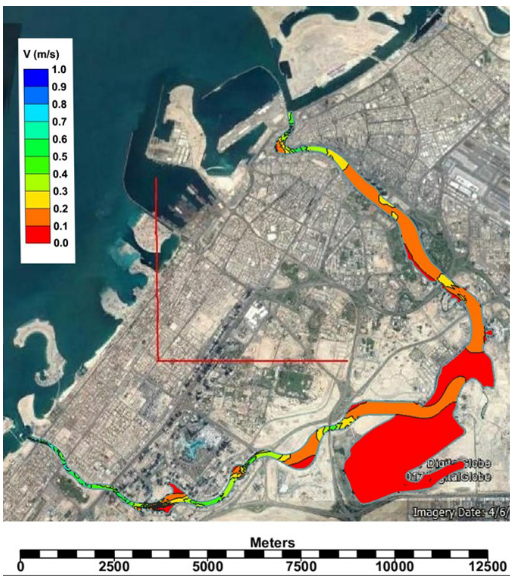

Figure 2. Velocity simulation of the average flow depth condition in the Dubai Canal (y=5.0 m, Q=300 m^3/s)

This part of the study is therefore concerned with the assessment of the hydraulic behaviour of the Dubai Canal and the evaluation of the velocities in order to determine whether its dimensions would favour or not undesirable stagnant water areas in the canal bends and lagoons (Figure 2). This is, perhaps, the most important aspect of the development of the Dubai Canal because such condition has the potential to compress real estate values along its banks and negate its intended function as massive waterway transportation route and recreation hub for hundreds of thousands of people.

4. LANDSCAPE AND EMERGING PUBLIC SPACE ALONG THE NEW DUBAI CANAL

Dubai represents a city that is in constant progress and aspires for better livelihoods, yet with its representation of spaces of hope the customary practice of mass-commoditization and consumption reaches its pinnacle. Dubai's malls and themed-gated communities revive the nostalgia to imaginary pasts through the creation of new-panoramas around artificial lagoons and canals. The Dubai Canal creates new public spaces along its banks and connects the historic urban enclave along Khor Dubai to the modern city, interlacing lagoons and crossing the main highway known as Sheikh Zayed Road, however, in the process the canal devoured part of Al-Safa Park warranting its redesign (Figure 3).

Figure 3. The redesign of Al-Safa Park in light of the Dubai Canal (photo-credit: Google Earth, photo by authors)

The investment to create a main water canal from the boundaries of Diera onwards manifests the constant desire of Dubai authorities to create new real estate properties along this canal as part of Dubai developments. The project includes excavation of the water canal, lining of its boundaries, and constructing a number of bridges to cross the canal. The project includes also the construction of 12 marine transit stations to enable convenient and effective water-transportation in order to link Dubai's several man-made islands to the downtown. According to the Roads and Transport Authority (RTA), the canal will offer new means of public transportation for one million Dubai residents and will become part of the mass transit network of Dubai (El Amrousi, M., Caratelli, & Shakour, 2014). The new Dubai Canal is 2.8 km long, 80 m wide and 6 m deep, and will integrate the historic Khor Dubai, through the Al-Safa Park, with the shorefront passing through downtown Dubai, near the Burj Khalifa area, and its surrounding artificial lagoons (McClatchy-Tribune Business News, 2012). The canal will receive its water from the sea and will deliver it back to the sea. Bringing together the functions of a city of living, working, circulating, learning, creating, and relaxing, which have been separated during the twentieth-century. The aim of artificial canals, such as the Dubai Canal, is to integrate buildings with nature, centre with periphery, local character with global forces, the various professions involved with urban growth and development, and people of different ethnicities, incomes, ages and abilities (Ellin, 2010). The new canal also manifests how Dubai is seeking to enhance its image and urban visibility. Engineered waterfronts as new assemblages of exclusion and inclusion offer new spaces of leisure for the community, while physically still remaining in proximity to their own country (Gupta, 2015). What may be regarded today as engineered water canals reflects the State's role to invest in green infrastructure in order to improve the liveability of the city and public health (El Amrousi, Mohamed et al., 2018). New open spaces created by waterfronts and canals integrated within an urban context, though engineered and sanitized, encourage the belief that the city has the ability to change its urban fabric focus from one that had concentrated on high-end real-estate and iconic architecture to a new, more inclusive to multi-ethnic socio-cultural groups, perception. The collage of hybridized buildings along the canal frames history and modernity beyond the geo-political context with the intention to substitute for the absence of a profound reality that unevenly binds spaces together across cities, regions, nations and international boundaries whilst helping also to define the material and social dynamics, and divisions, within and between urban spaces (Graham, 2001). Despite the plurality of interpretation of the past that overlaps the symbolic and spatial orders of real and hyper-real, such waterfront projects offer brief tastes of reality triggered by nostalgia to the historic Dubai and its origins as a port city. This validates the remaining presence of local tradition through diverse cultural produce and open spaces and landscapes (Steiner, 2010). Such usage of collaged forms and fragments of local tradition represent a contrasting image to the actual past with the remaking of a historic narrative, where the notion of authenticity and reference to the past is coupled by post-modernity and technological advancement (Young, 2006).

5. SIMULATION OF THE FLOW IN THE DUBAI CANAL

The Dubai Canal is classified as an estuary canal because it is connected to the Arabian Gulf Sea. The canal has rigid boundaries and can be designed using standard open channel hydraulics practice accounting for factors such as best efficient section and freeboard. However, the canal has several lagoons and bends in addition to the wave and tide effects due to its connection to the Arabian Gulf Sea. All those factors make the geometry and the hydrodynamics of the flow field in the canal of a complex nature, which were investigated by a computational 2D hydrodynamic model. The 2D hydrodynamic model simulations can provide detailed information of the flow field in the canal and lagoons under various hydraulic conditions (Chaudhry, 2008). In this study, the 2D Finite Element Surface Water Modelling System (FESWMS) is used to investigate the flow pattern in the canal. FESWMS is part of the commercially available Surface water Modelling System (SMS) package version 10.2 Graphical Interface that combines a series of hydrodynamic/ sediment codes (Froehlich, 2002). The model was successfully used to simulate flow in streams with bends and lagoons similar to the Dubai Canal (Elhakeem, Papanicolaou, & Wilson, 2017).

FESWMS solves the differential forms of the continuity and the momentum equations in the stream-wise and transverse directions using the Galerkin method of weighted residuals, providing water depth and depth-averaged velocity magnitude in x and y directions at each node in the grid (Hicks & Mason, 2001). The governing equations are written in the conservative form, hence the momentum is conserved along the streamline and the model is capable of capturing shock effects (Chaudhry, 2008). The conservative form was chosen because of its robustness in solving critical and transcritical flow fields under both low and high flow conditions by allowing dry-elements to exist within the computational mesh (Froehlich, 2002).

FESWMS solves the following equations simultaneously:

$$\frac{\partial z_w}{\partial t}+\frac{\partial q_1}{\partial x}+\frac{\partial q_2}{\partial y}-q_m=0 \tag{1}$$

$$\begin{aligned}&\frac{\partial q_1}{\partial t}+\frac{\partial}{\partial x}\left(\frac{q_1^2}{d}+\frac{1}{2}gd^2\right)+\frac{\partial}{\partial y}\left(\frac{q_1 q_2}{d}\right)+gd\frac{dz_b}{\partial x}\\&+gn^2\frac{q_1\sqrt{q_1^2+q_2^2}}{d^{7/3}}\sqrt{1+\left(\frac{\partial z_b}{\partial x}\right)^2+\left(\frac{\partial z_b}{\partial y}\right)^2}\\&-2d\varepsilon_{xx}\frac{\partial^2\overline{u}}{\partial x^2}-\varepsilon_{xy}\frac{\partial}{\partial y}\left(\frac{\partial\overline{u}}{\partial x}+\frac{\partial\overline{v}}{\partial y}\right)=0\end{aligned} \tag{2}$$

$$\begin{aligned}&\frac{\partial q_2}{\partial t}+\frac{\partial}{\partial x}\left(\frac{q_1 q_2}{d}\right)+\frac{\partial}{\partial y}\left(\frac{q_2^2}{d}+\frac{1}{2}gd^2\right)+gd\frac{dz_b}{\partial y}\\&+gn^2\frac{q_2\sqrt{q_1^2+q_2^2}}{d^{7/3}}\sqrt{1+\left(\frac{\partial z_b}{\partial x}\right)^2+\left(\frac{\partial z_b}{\partial y}\right)^2}\\&-2d\varepsilon_{yy}\frac{\partial^2\overline{v}}{\partial y^2}-\varepsilon_{yx}\frac{\partial}{\partial x}\left(\frac{\partial\overline{u}}{\partial x}+\frac{\partial\overline{v}}{\partial y}\right)=0\end{aligned} \tag{3}$$

where Eq. (1) is the continuity and Eqs. (2) and (3) are the momentum equations in x and y directions, respectively. In the equations, t is time (s), d is water depth (m), ρ is water density (kg/m^3), g is the acceleration due to gravity (m/s^2), n is Manning's coefficient of roughness, z_w and z_b are water surface elevation and bed elevation above certain datum (m), q_1 and q_2 are the unit discharge fluxes (m^2/s) defined as $\overline{u}_d$ and $\overline{v}_d$, respectively, $\overline{u}$ and $\overline{v}$ (m/s) are the depth-averaged velocities of an element in the stream wise and transverse directions, respectively, q_m is the resultant inflow or outflow from that element (m/s), ν_{xx} and ν_{yy} are the normal components of the eddy viscosity (m^2/s) in the x and y directions, respectively, and ν_{xy} and ν_{yx} are the shear components of the eddy viscosity (m^2/s) applied to the $x-y$ plane.

FESWMS inputs are the Manning's coefficient of roughness n, and the eddy viscosity ν. Manning's n is an empirical coefficient that accounts for the total flow resistance caused by flow interaction with the boundary (Papanicolaou, A.N et al., 2011). FESWMS utilizes Manning's n to account for momentum loss due to bed-shear, which may vary significantly in a stream reach in accordance to bed-bathymetry and roughness. The second input variable used by FESWMS is the eddy viscosity ν. Eddy viscosity accounts for flow resistance due to the internal shear stresses, or the Reynolds' stresses of the fluid incorporating the added energy dissipation due to turbulence in the flow (Papanicolaou, Athanasios N & Hilldale, 2002). Therefore, eddy viscosity is not a physical property of the fluid, but rather a turbulent characteristic of the flow. For isotropic flows in prismatic canals, a single eddy viscosity value is sufficient to describe the turbulence flow characteristics within the modelled reach.

The appropriate size of the mesh elements of the simulated reach can be estimated from the mesh Peclet number criterion, defined as the ratio of advection to diffusion occurring in an element (Tannehill, Anderson, & Pletcher, 1997). This can be expressed mathematically as:

$$P_e = UR / \nu_t \quad (4)$$

where U (m/s) is the resultant depth-averaged velocity of the element ($U = \sqrt{\overline{u}^2 + \overline{v}^2}$), ν_t is the eddy viscosity (m^2/s) in the flow direction ($\nu_t = \sqrt{\varepsilon_{xx}^2 + \varepsilon_{yy}^2}$), and R is the maximum distance between two nodes on the element (m).

The mesh Peclet equation shows that U and ν_t determine the ideal element size R and thus the minimum eddy length that can be resolved. However, the element size is also a function of local bathymetry including bed roughness, and tailoring a mesh grid design to ensure a constant mesh Peclet number throughout the reach is laborious and unreasonable. It is therefore sufficient to keep the mesh Peclet number within the recommended range for all the elements in the computational mesh. Prior studies using FESWMS (Elhakeem & Papanicolaou, 2008) recommended a mesh Peclet number between 10 and 40 to ensure that: 1) momentum is dominated by advection; 2) eddy viscosity maintains flow consistency and prevents oscillation; and 3) proper amount of energy loss due to dispersion takes place in each element to account for micro eddies, which are too small to be resolved in the mesh (i.e., those eddies that are smaller than the local element size). Keeping the mesh Peclet criterion within the recommended range and resolving for the ideal element size R minimises the errors that can result from the spatial resolution of the computational mesh (Elhakeem & Papanicolaou, 2008).

Although FESWMS possesses the capability of spatially distributing both Manning's n and eddy viscosity in the computational mesh, it is common to use averaged values for Manning's n and eddy viscosity. In prismatic canals, an average eddy viscosity value can be assigned to the study reach as a function of depth and bed slope (King, I. P., 1992). The Dubai Canal has a rectangular cross-section with an average width of 80 m and wider width at the lagoon sections. The model inputs are: the canal bathymetry, Manning's coefficient n = 0.025, eddy viscosity ν = 0.3 m^2/s, flow rate at the upstream Q = 300 m^3/s, and water surface elevation at the downstream y = 5.0 m. Figure 4 shows the water velocity distribution and the complex circulation pattern, respectively in the canal and lagoons. Velocity is in the range of 0.3 to 1.2 m/s with higher values in the canal sections and lower values in the lagoons sections. The model predictions show that the water velocity is higher in the canal sections compared to the lagoons and bends sections.

Figure 4. Velocity vectors of the average flow depth condition in the Dubai Canal

(y = 5.0 m. Q = 300 m3/s)

It is clear from the figure that the model was able to mimic the expected flow field in the canal and circulation patterns in the lagoons. Based on the simulation of the Dubai Canal the recommended minimum velocity in rigid boundary canals should be in the range of 0.4 m/s such that sediment is not deposited, aquatic growth is inhibited, and sulphide formation does not occur, while recommended maximum velocity should be in the range of 6.0 m/s to avoid boundary erosion (Chaudhry, 2008). In addition, the Froude number ($F_r = U / \sqrt{gy}$) should be less than 0.3 so that the water surface does not become rough, especially downstream of obstructions and in bends. From the model simulation, it can be seen that the velocities as well as the Froude number in the Dubai artificial canal are within the accepted range recommended for rigid boundary canals. The canal on its final shape connected from both ends to the Arabian Gulf Sea allowed for full circulation of its water and minimised the formation of stagnant areas, which promote sediment deposition and algae growth causing foul-smelling waters.

6. DISCUSSION AND CONCLUSION

The new Canal-scape will offer a sense of emerging public space cultivating a sense of orientation, especially in a city that is heavily reliant on an image of creating projects that are challenging from an engineering perspective and in terms of sustainability. There is no doubt that today the Arab world, and especially the Gulf state cities are becoming urban, at diverse rates and with comparable characteristics, and have become more connected to a globalized realm beyond that of their hinterland (Malkawi, 2008). This form of urbanism is what Kenneth Frampton coins as the 'Catalytic City', a city composed of a group of super-structures that construct mini-cities and introverted urban enclaves leaving the remaining landscape (Frampton, 2003). Open spaces along the banks of the new Canal have even changed the experience of space in Al-Safa Park. In accordance with the function of open space the park lost part of its green space in favour of a newly created waterfront that has taken on a new role in the establishment of space for social activities and recreation (Wikantiyoso & Suhartono, 2018). Furthermore, Dubai's new Mohammed Bin Rashid Library, depicted as an open book (Figure 5), is a good example of newly emerging public monuments that would adorn areas of remaining landscapes, creating new public spaces. The new post-modern architectural icon reshapes the image of Dubai from one primarily catering to capitalism to one that incorporates socio-cultural activities. The complex architectural project is one of the largest cultural projects in Dubai, a significant change from high-end secluded spaces. The new library includes landscaping, and infrastructure for roads and pavements, initiating new concepts of public space in Dubai (www.constructionweekonline.com). Such cultural icons along the boundaries of the Dubai Creek extended by the Dubai Canal will become spaces to stage new but more or less convincing narratives of post-modernity by weaving narratives of hybrid traditions that build on chosen sections of 'modern' heritage and distant history to satisfy touristic demands for "new" experiences. The experience here draws on parallels between remnants of Dubai's real heritage and its hyper-real reconstruction that has surpassed it in scale (Baudrillard, 1988). It represents a strategic and innovative concept project that reflects an increasingly connected and interrelated world especially in rapidly developing economies (Li & Dang, 2014).

Figure 5. The new Mohammed Bin Rashid Library (photo-credit by the authors)

In particular, the new Dubai Canal will enhance the urban-scape of the city offering new waterfront developments, transportation venues and diversified panoramas to the city. The new Canal fosters open spaces around it that act as counter spaces to high-end real-estate projects and that can provide environmental and social sustainability in the long run, especially if similar projects materialise and become part of Dubai's broader urban policies (Huang, Pai, & Liu, 2016). Emerging open spaces in cities that have witnessed rapid urbanisation are necessary, and when mitigated they represent an intermediate intervention of government, private sector and the emergence of local governments as entrepreneurs.

Finally, this study was concerned with the assessment of the flow field and the hydraulic behaviour of the Dubai Canal. This is, perhaps, the most important aspect of the Dubai Canal project. The canal in its final shape connects from both ends to the Arabian Gulf Sea allowing for full circulation of its water and minimised areas of stagnant water, which can promote algae and bacteria growth leading to foul-smelling waters. This situation would endanger the Canal's intended function as a massive water-way transportation and recreation hub for hundreds of thousands of people and could drastically reduce real estate values in the developments planned along its banks. This studies' model predictions showed that velocities in the canal are within the accepted range that prevents boundary erosion and sediment deposition. In addition, the Froude number was in the range that averts the water surface from becoming rough, especially in the bends sections.

REFERENCES

Acuto, M. (2010). "High-Rise Dubai Urban Entrepreneurialism and the Technology of Symbolic Power". *Cities*, *27*(4), 272-284.

Baudrillard, J. (1988). "Simulacra and Simulation". In Baudrillard, J. & Poster, M. (Eds.), *Selected Writings*: Stanford University Press.

Branzi, A. (2006). *No Stop City, Archizoom Associati.* Orleans: Hyx.

Chaudhry, H. M. (2008). *Open-Channel Flow.* (2nd ed.). Columbia, SC: Springer.

Davis, M. (2007). "Sand, Fear and Money in Dubai". In M Davis & Monk, D. B. (Eds.), *Evil Paradises: Dreamworlds of Neoliberalism* (pp. 48-68). New York, NY: New Press.

El Amrousi, M., Caratelli, P., & Shakour, S. (2014). "Open Cities". Proceedings of ACSA/AIK International Conference 2014, Seoul, Korea.

El Amrousi, M., Paleologos, E. K., Caratelli, P., & Elhakeem, M. (2018). "Are Garden Cities in the Desert Sustainable? The Oasis City of Al Ain in the Emirate of Abu Dhabi". *International review for spatial planning and sustainable development*, *6A*(1), 79-94.

Elhakeem, M., Papanicolaou, A., & Wilson, C. G. (2017). "Implementing Streambank Erosion Control Measures in Meandering Streams: Design Procedure Enhanced with Numerical Modelling". *International journal of river basin management*, *15*(3), 317-327.

Elhakeem, M., & Papanicolaou, A. N. (2008). "Evaluation of the Reduction in the Water Storage Capacity of Black Lake, Ak". *International journal of river basin management*, *6*(1), 63-77.

Ellin, N. (2010). "Canalscape: Practising Integral Urbanism in Metropolitan Phoenix". *Journal of Urban Design*, *15*(4), 599-610.

Frampton, K. (2003). "The Catalytic City: Between Stratety and Intervention". In van Oers, R. & Haraguchi, S. (Eds.), *Identification and Documentation of Modern Heritage* (pp. 72-78). Paris: UNESCO World Heritage Centre.

Froehlich, D. C. (2002). *User's Manual for Feswms Flo2dh: Two-Dimensional Depth-Averaged Flow and Sediment Transport Model.* McLean, VA: Federal Highway Administration.

Graham, S. (2001). "Guest Editorial: The Spectre of the Splintering Metropolis". *Cities*, *18*(6), 365-368.

Grydehøj, A. (2015). "Making Ground, Losing Space: Land Reclamation and Urban Public Space in Island Cities". *Urban Island Studies*, *1*, 96-117.

Gupta, P. (2015). "Futures, Fakes and Discourses of the Gigantic and Miniature in 'the World' Islands, Dubai". *Island Studies Journal*, *10*(2), 181-196.

Haines, C. (2011). "Cracks in the Façade: Landscapes of Hope and Desire in Dubai". In Roy, A. & Ong, A. (Eds.), *Worlding Cities: Asian Experiments and the Art of Being Global*: Wiley Online Library.

Hicks, D. M., & Mason, P. D. (2001). "Roughness Characteristics of New Zealand Rivers". *Journal of Hydraulic Engineering*, *127*(6), 526 - 527.

Huang, K.-H., Pai, J.-T., & Liu, J.-H. (2016). "Study of Performance Assessment for Urban Renewal Project in Taipei City". *International review for spatial planning and sustainable development*, *4*(1), 64-77.

King, A. (2004). *Spaces of Global Cultures: Architecture, Urbanism, Identity.* New York, NY: Routledge.

King, I. P. (1992). "Evaluation of Modelling Parameters for Simulation of Estuarial Systems". Proceedings of 2nd Estuarine and Coastal Modeling, Tampa, Florida, pp. 707-719.

Li, Y., & Dang, A. (2014). "Editorial Introduction: Special Issue on “Sustainability Indicators and Analysis”". *International Review for Spatial Planning and Sustainable Development*, *2*(3), 1-3.

MacCannell, D. (1973). "Staged Authenticity: Arrangements of Social Space in Tourist Settings". *American journal of sociology*, *79*(3), 589-603.

Malkawi, F. K. (2008). "The New Arab Metropolis: A New Research Agenda". In Elsheshtawy, Y. (Ed.), *The Evolving Arab City - Tradition, Modernity and Urban Development* (pp. 27-36). New York: Routledge.

McClatchy-Tribune Business News. (2012). "Business Bay Canal Extension Set to Energize Dubai's Landscape". Washington: McClatchy-Tribune Business News.

Papanicolaou, A. N., Elhakeem, M., Dermisis, D., & Young, N. (2011). "Evaluation of the Missouri River Shallow Water Habitat Using a 2d-Hydrodynamic Model". *River Research and Applications*, *27*(2), 157-167.

Papanicolaou, A. N., & Hilldale, R. (2002). "Turbulence Characteristics in Gradual Channel Transition". *Journal of Engineering Mechanics*, *128*(9), 948-960.

Steiner, C. (2010). "From Heritage to Hyper-Reality? Tourism Destination Development in the Middle East between Petra and the Palm". *Journal of Tourism and Cultural Change*, *8*(4), 240-253.

Tannehill, J. C., Anderson, D., & Pletcher, R. H. (1997). *Computational Fluid Mechanics and Heat Transfer.* (2nd ed.). Philadelphia, PA: Taylor & Francis Publisher.

Wikantiyoso, R., & Suhartono, T. (2018). "The Role of Csr in the Revitalization of Urban Open Space for Better Sustainable Urban Development". *International Review for Spatial Planning and Sustainable Development*, *6*(4), 5-20.